Crystal Growth and Energy Transfer in Cr^{2+}:CdSe and Cr^{2+}:CdS_xSe_{1-x}

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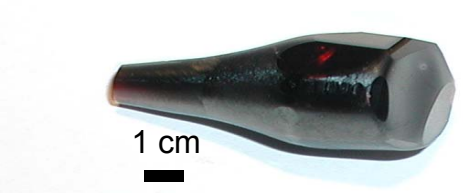
A new solid-state infrared laser material, based on a solid-solution ternary selenide host was discovered in this project. These eyesafe lasers can be used for a variety of purposes including biochemical sensors, pollution monitoring (ozone, particulate matter and industrial emissions), atmospheric trace gas monitoring (ex. water vapor) and meteorological studies and wind sensing (detection of aviation hazards such as clear air turbulence, wind shear and wake vortexes). The room temperature operation, compactness, low weight and cost, as well as tunability in a wide infrared spectral range are some unique advantages of this new class of materials.

As an outcome of the project an international collaboration was established with the Institute of Photonics, University of Strathclyde, Glasgow Scotland, UK. In collaboration with Drs. David Burns and Pavel Cerny we were able to develop the next generation' Cr^{2+}-doped crystals, including Cr:CdZnTe material which was just demonstrated to sustain lasing in CW at 4 mW around 2.8 micron.

We also developed a research relationship with the NSF supported Center for Biophotonics (an STC led by UC Davis) and are presently proposing an infrared biomedical sensor for the noninvasive determination of glucose in blood.



Photograph of a crystal of Cr^{2+} :$CdS_{0.8}Se_{0.2}$ grown at Fisk

Fisk student next to the crystal growth system he helped build.

Efficient room temperature lasing has been demonstrated with tetrahedrally-coordinated Cr^{2+} active ions doped into II–VI chalcogenides such as ZnSe and CdSe [1-3]. For many of the high power applications, the thermophysical properties of the host material are of critical importance. The new host crystal prepared and investigated in this project, CdS_xSe_{1-x}, has the advantage of improved thermal conductivity compared to CdSe and thus might be considered as a superior laser host. The crystals were doped during growth by the physical vapor transport and by the Bridgman methods. Optical measurements performed in this project revealed the room temperature mid-infrared absorption spectrum of Cr^{2+}: CdS_xSe_{1-x} reveals a peak at 1.9 μm corresponding to the intercenter transition $^5T_2 \rightarrow {}^5E$ of Cr^{2+} and was found to vary slightly compared to the variation in the energy of the band gap. As a result the probability for excited state absorption is decreased for the ternary CdS_xSe_{1-x} compared to the lower bandgap CdSe. Cr^{2+} ions are therefore especially attractive as laser centers on account of high luminescence quantum yields (approx. 68% for Cr^{2+}: CdS_xSe_{1-x}) for emission in the 2–3 mm range.

References

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Education:

This project provides education and mentoring of undergraduate and graduate students which are under-represented in physics and in materials science. group provides training of minority students in materials research. Supported by this NSF grant were three graduate students and four undergrads. Presentation at the Fisk Summer Research Program, Fisk University: "Lasers and their Applications in Biophotonics" by Arnold Burger. A total of 32 undergrads and grads (physics, chemistry, biology and computer science and mathematics majors) working in the summer research program at Fisk have attended.

Outreach and service to scientific community:
This project provides education and mentoring of undergraduate and graduate students which are under-represented in physics and in materials science. A series of three science presentations and demos at MLK Magnet High School for For Health Sciences and Engineering were delivered by Dr. Burger. A total of 74 highschool juniors (2/3 were females or underrepresented minorities) were impacted. The students have been to the topic of lasers and their biomedical uses, as well as biological and chemical sensor applications. Dr. Burger has interacted and acted as a resource for two MLK science teachers, Dr. John Lee and Mr. Chand Desai.

Photo below: Dr. Burger during a presentation at MLK Magnet school